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TABLE OF CONTENTS

SUMMARY 1

INTRODUCTION 4

PURPOSE OF MONITORING PROGRAM 4

POLLUTANTS AND THEIR MEASUREMENT 5

Particulate Matter 5

Gaseous Pollutants 6

Sulphur Dioxide 6
Total Reduced Sulphur 7
Ozone 7
Nitrogen Oxides 8
Miscellaneous 8

RESULTS AND DISCUSSION 9

ATIKOKAN 9

Ontario Hydro Generating Station 9
Particulate Matter 9
Pluswood Manufacturing Limited 10

BALMERTOWN 10

Arsenic 10
Mercury 11
Sulphur Dioxide 11

DRYDEN 12

Vegetation Effects 12

Lagoon 12
Kraft Mill 13

Dustfall 13
Odour Levels 13

FORT FRANCES 14

Vegetation Effects 14
Particulate Matter 15
Odour Levels 16

KENORA 16

Vegetation Effects 16
Particulate Matter 17
Sulphation Rates and Sulphur Dioxide 17

LONGLAC 17

Particulate Matter 17

MARATHON 18

Odour Levels 18
Mercury in Surface Drainage Water and in Soil 18

RED ROCK 19

Particulate Matter 19
Odour Levels 20

TERRACE BAY 20

Odour Levels 20

THUNDER BAY 21

Particulate Matter 21

Dustfall 21
Suspended Particulate Matter and Soiling Index 22

Gaseous Pollutants 22

Sulphur Dioxide (SO_2) 22
Total Reduced Sulphur (TRS) 23
Ozone (O_3) 23

Special Studies 23

Pulp Mills 23
Thunder Bay Terminals Limited 23
Ontario Hydro - Thunder Bay Generating Station 24
Hawkeye Lake Acid Rain Study Site 24

ACKNOWLEDGEMENTS 25

REFERENCES 26-27

FIGURES AND TABLES 28-55

SUMMARY

This report presents results of the Ministry's air quality assessment program in northwestern Ontario for 1983. It includes data from 10 communities where long-term monitoring is conducted, plus summaries of special studies in the Thunder Bay area.

ATIKOKAN

Pre-operational sampling was carried out for a second year near Ontario Hydro's power plant at Atikokan. Residual arsenic and iron contamination was again found in vegetation and soil around formerly active iron ore mines.

Suspended particulate matter, monitored at the Atikokan Weather Station, continued to be recorded at satisfactory levels.

A snow sampling survey at the Pluswood particle board plant revealed a decline in fallout of wood fibres after the company improved emission controls.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Arsenic and mercury met guidelines in all vegetable samples from residential gardens.

In 1983, there were 64 sulphur dioxide readings above the maximum acceptable limit down from 104 such occurrences in 1982. Vegetation damage from sulphur dioxide was restricted to a few small, scattered areas, nearly all of which were on company property. This improvement is at least partly attributed to a voluntary sulphur dioxide emission reduction program implemented by Campbell Red Lake Mines Limited.

DRYDEN

A vegetation survey near the recently modernized Great Lakes kraft pulp mill showed that levels of elements in tree foliage were normal.

As a result of earlier abatement action at the Dryden mill, dustfall continued to substantially comply with Ontario regulations.

Odour levels caused by total reduced sulphur (TRS) showed a further decline in 1983, continuing the trend started in 1982. This improved air quality is due to better controls on odour emissions from the mill.

FORT FRANCES

The zone of vegetation injury near the Fort Frances kraft pulp mill was the smallest recorded since the mill was constructed, and was confined to a company-owned buffer zone around the mill.

Dustfall and suspended particulate matter showed little change from preceding years. Emissions of wood fines from mill property sometimes contributed significantly to elevated dustfall readings.

TRS levels declined in 1982, but still frequently exceeded the provincial guideline.

KENORA

No vegetation damage complaints were received in 1983. Dustfall was generally acceptable.

LONGLAC

An air quality monitoring network was established in Longlac in late 1983. No conclusions could be drawn from the few sample results available.

MARATHON

Average airborne sulphur levels have shown little change during recent years. Concentrations of reduced sulphur exceeded the provinical guideline on 25 occasions at the Ministry's monitoring station in the townsite.

There was very little mercury in surface water draining soil on company property near the kraft pulp mill at Marathon. Mercury in the soil itself was higher than in 1981 at some sites because of mercury discharges during dismantling of equipment in the mill's old chlor-alkali plant.

RED ROCK

Dustfall and TRS both decreased sharply in 1983 at Red Rock following completion of a major modernization program, including a new recovery furnace, at the Domtar kraft pulp mill.

TERRACE BAY

Reduced sulphur was above the Ontario guideline for 30 hours in 1983 because of emissions from the Kimberly-Clark kraft pulp mill in the community. The Ministry is negotiating with the company to secure further reductions in emissions of odour-causing reduced sulphur compounds. Data from the Ministry's air quality monitor in the townsite are telemetered to the mill to warn of pollutant levels above desirable concentrations.

THUNDER BAY

Average dustfall in Thunder Bay in 1983 was well within the acceptable range and has been essentially unchanged for several years. Periodically, high readings at two sites in the Westfort area were caused by flyash emissions from Great Lakes Forest Products Limited. Dustfall at these locations decreased at the end of the year when the company installed dust control equipment on its power boilers.

Suspended particulate matter in the air was satisfactory during the year, with 97 percent of the samples meeting the Ontario air quality objective.

With the exception of one hour at one site, full compliance was achieved for all air quality objectives for sulphur dioxide at the nine sites where this pollutant is measured. Total reduced

sulphur (TRS) levels near Great Lakes Forest Products Limited also improved during the year. The TRS guideline was exceeded only 3 times in 1983, compared with 7 times in 1982 and 72 times in 1981.

Ozone, a pollutant usually associated with long-range transport, met the Ontario air quality objective at all times.

INTRODUCTION

PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts an air quality assessment program throughout the province. This program monitors, in outdoor air, the levels of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys record compliance with air quality objectives, evaluate the need for and results of pollution controls, and determine long-term trends in air quality.

In northwestern Ontario, air quality surveys first began in 1963 to measure airborne dust in the City of Thunder Bay. By 1983, the program had expanded to include eight pollutants, monitored by more than 90 instruments in 10 urban centres. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan. Data from air quality instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mining, pulp and paper). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is now a major environmental issue in eastern North America and parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and developing possible answers to this problem. The

Ministry's Northwestern Region participates in this program through precipitation sampling surveys and research on the aquatic and terrestrial effects of acid rain. The findings of these studies are reported elsewhere.

One of the future goals of the air quality program in northwestern Ontario is to install a telemetry system to improve the quality of data and the speed with which it is received. Such a system, expected by 1985, will permit us to obtain immediate readings from any continuous monitor in the region.

POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario will be considered. Carbon monoxide and hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

Particulate Matter

There are many man-made and natural sources of particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), or soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed (1). The monthly air quality objective (maxiumum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days).

Dustfall provides an estimate of fallout of particulate matter from local sources, including dust from nearby construction or from vehicular traffic.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This matter may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day (2). The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air) averaged over 24 hours, or 60 $\mu g/m^3$, annual geometric mean.

Soiling index is a measure of soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is probably closely related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every two hours. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

Gaseous Pollutants

Sulphur Dioxide

Sulphur dioxide, total reduced sulphur, nitrogen oxides, and ozone are currently monitored in northwestern Ontario. Sulphur dioxide (SO_2) is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to the formation of acid rain. In northwestern Ontario, the principal SO_2 sources, which are small compared to those in some other parts of the province, are the Ontario Hydro generating station in Thunder Bay, sulphite pulp mills, industrial boilers, and gold ore roasting. SO_2 is measured with passive samplers (sulphation

plates) to provide a semi-quantitive estimate of the presence of sulphur-containing gases. Results are expressed as monthly sulphation rates, in mg SO_3/100 cm^2/d (milligrams of sulphur trioxide per 100 square centimetres of treated filter paper per day). Sulphur dioxide is also monitored with continuous analyzers (3). There are three air quality objectives for this pollutant: 0.25 ppm (parts of sulphur dioxide per million parts of air, by volume), hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

Total Reduced Sulphur

Total reduced sulphur (TRS) comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS source in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary respiratory irritation or may injure vegetation. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air, by volume), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS may be measured with sulphation plates, for semi-quantitative results, or with continuous analyzers (4).

Ozone

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a secondary product of reactions between nitrogen oxides and hydrocarbons. If it is present at high concentrations, it may adversely affect health and vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings suggest long-range transport from outside the region. Ozone is measured with continuous analyzers (5), and the current air quality objective is 0.08 ppm, averaged over one hour.

Nitrogen Oxides

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may affect health and visibility. Both compounds also enter into photochemical reactions with ozone and other oxidants, and contribute to the formation of acid rain. Nitrogen oxides are monitored with continuous analyzers (6). The air quality objectives for NO_2 are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

Miscellaneous

The occurrence and effects of some of the foregoing pollutants, as well as others, are also assessed by vegetation injury and by contaminant levels in vegetation, soil and snow. Standard Ministry procedures (7, 8, 9) are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride (10), sulphur and heavy metals are typical contaminants examined this way. Their levels in a study area are compared with normal background levels at sites unaffected by pollution. In 1984, the Ministry developed proposed contaminant guidelines for vegetation, soil and snow. These guidelines are used in this report. Their exceedance suggests that contamination is present, but does not necessarily imply an adverse effect.

Dustfall, sulphation, and suspended particulate matter determinations, as well as most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. Metals, nitrate, and sulphate in suspended particulate matter, and sulphur and halides in vegetation and soil, are analysed at the Ministry's Toronto laboratory. The Toronto laboratory also provides a service for the determination of unusual contaminants (e.g.: organic compounds such as PCB's or pesticides).

The Ministry's Air Resources Branch processes the strip charts from continuous analyzers, and produces computer printouts of all air quality data for the region. The Thunder Bay regional office has developed computer programs to improve access to air quality and meteorological data in Toronto.

RESULTS AND DISCUSSION

ATIKOKAN

Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began an environmental monitoring program around a lignite-fired generating station under construction near Atikokan. In the air quality part of this program, Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples (Figure 1). By 1984, when the 200-megawatt plant is completed, about three years of background data will have been collected.

Consultants for Ontario Hydro submit quarterly and annual air quality reports, and the Ministry prepares annual reports on terrestrial studies. The Ministry reports for 1981 and 1982 confirmed the presence of residual arsenic and iron contamination in vegetation and soil near the power plant. The source of these contaminants was emissions from nearby iron ore pelletizing plants which operated from the mid-1970's to about 1980 (11). The Ministry and Ontario Hydro plan to continue their monitoring programs for several years after the generating station is commissioned to ensure compliance with environmental regulations.

Particulate Matter

At the Ministry's monitoring site in the Town of Atikokan, TSP fully complied with the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 22 $\mu g/m^3$ was also well below the maximum acceptable limit of 60 $\mu g/m^3$.

Pluswood Manufacturing Limited

A snow sampling survey in 1981 showed that fallout of wood fibres emitted from Pluswood's particle board plant in Atikokan caused a local nuisance (12). Abatement measures taken by the company to reduce emissions of particulate matter resulted in a significant decrease in the fallout of wood fines when the survey was repeated in 1983 (13). Additional controls on the discharge of wood particles are now being installed at Pluswood. A third survey is planned for 1985 to assess the effectiveness of this action.

BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson-Sullivan Joint Venture, Arthur W. White Mine (formerly Dickenson Mines Limited), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson changed its ore processing methods and shut down its roaster.

Arsenic

Campbell Red Lake Mines carried out a regular air monitoring program for several years after arsenic emission controls were introduced at its mill in 1974. Arsenic in these samples, from the centre of the townsite, were consistently well below the maximum acceptable limit for airborne arsenic (14).

In 1983, arsenic concentrations in leaves of trembling aspen trees at 16 sites near the mines (Figure 2) remained elevated on company property but were near normal levels in the townsite (Figure 3). A snow sampling survey showed a similar pattern of contamination. Arsenic in vegetation on company property was lower in 1983 than 1982. The elevated arsenic near Campbell's

ore roaster is attributed to fugitive emissions during roaster start-up or shutdown, or to emissions when trucks are loaded with arsenic waste from the roaster baghouse. Table 1 compares arsenic readings for the past 12 years at selected sites on and off company property. Table 2 presents 11 years of data from planted roadside trees in the townsite. Arsenic levels in townsite trees are now about 98 percent lower than those recorded before emission controls were in place.

In garden vegetables, arsenic was again well below the limit (10 µg/g, dry weight) specified by the Health Protection Branch, Canada Department of Health and Welfare (Table 3). Because arsenic in garden soil remains high, residents are advised to thoroughly wash vegetables from Balmertown gardens.

Mercury

Because mercury has been used in ore processing at the mines, the Ministry has regularly examined mercury concentrations in local vegetation, soil and snow. The 1983 data show that mercury was slightly elevated in vegetation and snow close to the mines, but was normal in the townsite. All samples of vegetables from residential gardens met the recommended international guideline for mercury (0.5 µg/g, dry weight). Campbell Red Lake recently discontinued the use of mercury in ore processing.

Sulphur Dioxide

Sulphur dioxide (SO_2) sometimes exceeds desirable levels in Balmertown. In 1983, the Ministry's Balmertown monitor recorded 65 hourly readings and two, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.57 ppm, about twice the Ontario objective. The annual average (0.008 ppm) was satisfactory. Elevated SO_2 during the growing season injured trees and shrubs in several small, scattered areas (Figure 4).

The number of exceedences of the 1-hour and 24-hour SO_2 objectives were much lower in 1983 than in 1982. The maximum hourly reading and the annual average concentration were also

lower. During the growing season (May to September), SO_2 was above the acceptable hourly limit only 10 times, compared with a minimum of 24 times in any of the preceding five years. Similarly, the total area of vegetation damage in 1983, nearly all of which was on company property, was down sharply from the 33 hectares reported in 1982. This improvement appears to reflect the implementation of a voluntary emission reduction program by Campbell Red Lake Mines Limited. Under this program, the company suspends ore roasting when the wind carries roaster-stack emissions over the townsite during the growing season. The current Control Order requires the company to submit quarterly reports to the Ministry on roaster shutdowns due to this SO_2 abatement program. The Ministry expects that this action will reduce or eliminate vegetation damage formerly occuring in the townsite.

DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and adjacent chlor-alkali plant in Dryden. Our earliest surveys showed that mercury, particulate matter and offensive odours around the mill were often well above normal levels. Abatement action and process changes in the 1970's successfully controlled the discharge of mercury and particulate matter. Mill modernization in the early 1980's reduced emissions of odour-causing TRS. In 1983, the Ministry continued to monitor dustfall and odours, and conducted two vegetation surveys.

Vegetation Effects

Lagoon

A new secondary treatment system (lagoon) was completed in late 1983 to treat liquid waste from the Dryden mill. Before the lagoon began operating, a moss exposure experiment was conducted to determine background air quality nearby. For 29 days in July, Sphagnum moss samples were set out at 12 sites near the lagoon and at two control locations. Analysis of the moss at the

conclusion of the study showed that chloride, mercury, and sodium levels were normal. This survey will be repeated in 1984, when the lagoon is operating.

Kraft Mill

To ensure that the recently modernized kraft pulp mill had not adversely affected air quality, a vegetation survey was carried out in August. Foliage from Manitoba maple and trembling aspen trees was sampled from 18 sites around the mill and from two control locations some distance from Dryden. Levels of chloride and sodium were normal in samples from the town and were not greatly different from those in previous surveys. Mercury declined slightly from the preceding study in 1979 and was normal in all samples. There were no symptoms of air pollution injury on any vegetation.

Dustfall

Total dustfall continued to be recorded at generally satisfactory levels at the six monitoring sites (Figure 5) in Dryden. Although dustfall easily met the annual objective at all locations (Table 4), the averages may be artifically low because no data were available for May and June. After improved dust emission controls were put in place at the mill in 1977, average dustfall levels in the town have been stable and satisfactory. Modernization of the kraft mill, completed in early 1983, also had no adverse effect on local dustfall. For these reasons, dustfall measurements were discontinued at the end of 1983.

Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with sulphation plates and with a continuous total reduced sulphur (TRS) analyzer. The data for 1983 (Tables 5 and 6) clearly show improved air quality. The maximum TRS reading (121 ppb), the annual average TRS concentration (1.5 ppb), and the number of hours of TRS above the provincial guideline were all below comparable figures for previous years. These declines

were ascribed to reduced emissions from the modernized mill. Fine tuning of the new mill to achieve best operation should result in furthur improvement in 1984.

FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in excessive fallout of particulate matter, high concentrations of malodorous gases, vegetation damage, and complaints from nearby residents. In recent years, a "buffer zone" has been created through purchase of adjacent residential land. Some emission reductions were also achieved and, in 1980, a Control Order was issued to obtain compliance with Ministry regulations.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and since 1974 near a similar plant owned by the same company on the U. S. side of the border (Figure 6). In addition to its routine air quality monitoring program in Fort Frances during 1983, the Ministry carried out a special air quality survey with mobile equipment in September and October. A report on this study was recently released (15).

Vegetation Effects

The zone of vegetation injury near the Fort Frances mill was the smallest recorded since the mill started production. Damage was restricted to a portion of the company's buffer zone (Figure 6) on the south side of Nelson Street (between Mowat and Portage), and along Portage Avenue (between Nelson and Sinclair). The severity of injury was less in 1983 than in 1982. Some trees even showed signs of recovery from past injury. No vegetation damage complaints were received from area residents. Chloride and sodium in foliage of Manitoba maple from 18 sites (Figure 6) were elevated in, and immediately adjacent to, the buffer zone

(Table 7). No visible vegetation injury was found off company property around the aeration lagoons at the secondary treatment system on Eighth Street (Figure 7).

Particulate Matter

Dustfall results for 1983 are summarized in Table 8. Total dustfall values are estimates only, since two months of data (for May and June) were lost because of analytical problems. Except at the two monitoring sites farthest from the pulp mill (stations 62032 and 62037), the annual air quality objective was not met. Insoluble dustfall was the primary cause of elevated readings at many sites. Wood fibres often comprised the largest fraction of insoluble dustfall at monitoring sites near, but outside, the boundaries of the mill's buffer zone. Fly ash was prominent in dustfall in July. A comparison of average dustfall over the past five years (Table 9) shows little change from 1979 to 1983, except for saltcake which dropped sharply after 1979. Snow samples collected in early 1983 also revealed little change from 1982: elevated saltcake in the buffer zone and above-normal carbon and suspended solids for 200-300 metres outside the zone. Carbon and suspended solids in snow were used as tracers of wood fines. Wood fibres were also microscopically identified as the main particulate substance in filtrate from snow collected inside and outside the buffer zone.

Total suspended particulate matter rose slightly from 1982. The annual average at the monitoring site near the mill (station 62035) was 63 $\mu g/m^3$. Eight daily readings, compared with seven in 1982, exceeded the 24-hour objective. Some samples at this site had visible amounts of wood fibres. The annual average TSP at the Fort Frances cemetery (station 62032) was 35 $\mu g/m^3$, which is normal for this location and well within the Ontario objective.

Odour Levels

Sulphation rate averages showed no change over the past three years (Table 10), but average TRS declined at the site nearest the Fort Frances kraft mill (station 62052 in 1983, formerly station 62030) (Table 11). Three factors probably contributed to this decrease. In late 1982, station 62030 was closed and was relocated to station 62052, slightly farther and at a slightly different direction from the mill. The second factor was the replacement, in early October, 1983, of an obsolete monitor with a new instrument which has less response than the former instrument to most TRS compounds. The third development was the incineration of non-condensible gases at the mill to reduce TRS emissions. All these factors could have resulted in lower TRS readings. Therefore, at present, we are uncertain whether the improvement in 1983 was apparent or real. In any case, there were still a large number of hourly readings (418 at station 62052, 345 at station 62051, and 180 at station 62032) exceeding the TRS guideline (Table 11). TRS at stations 62052 and 62051 would be influenced mostly by emissions from the Fort Frances kraft mill. Readings at station 62032 would be affected mainly by discharges from the kraft mill in International Falls, Minnesota, and to a lesser degree by TRS from the kraft mill and from the secondary treatment system (lagoon) in Fort Frances.

KENORA

The Ministry has conducted air quality studies for the past 13 years near a sulphite pulp mill in Kenora. Occasional upset conditions in this plant have caused localized vegetation damage, and fallout of particulate matter emitted from the mill's power boiler stack has sometimes been a nuisance to nearby residents.

Vegetation Effects

No complaints of air pollution damage to vegetation were received in 1983.

Particulate Matter

As Table 12 shows, average dustfall in Kenora in 1983 was the lowest recorded for several years. Dustfall exceeded the annual objective at only one of four sites in the monitoring network (Figure 8). Char and flyash particles from the mill's boiler stacks were responsible for the elevated dustfall readings sometimes recorded at station 61007. A new Control Order has been served to the company which will require full compliance with Ministry regulations for particulate matter.

Sulphation Rates and Sulphur Dioxide

Average sulphation rates were about the same in 1983 as in 1982 (Table 13). In August, 1983, a continuous sulphur dioxide monitor was installed on Fourth Street North (station 61030, Figure 8). All readings between mid-August and December were low and met provincial air quality objectives.

LONGLAC

Particulate Matter

A snow sampling survey at Longlac in February, 1983, found elevated levels of particulate carbon and wood fines around conical wood waste burners operated by two forest products industries (16). To obtain further air quality data near these emission sources, a monitoring network of five dustfall jars and one high-volume sampler was established in Longlac in late 1983 (Figure 9).

Of the 10 hi-vol samples collected at station 63070, one was slightly above the air quality objective. Wood fibres and a smoky aroma were present on filters on several sampling dates. No dustfall measurements were made. The survey will continue in 1984.

MARATHON

Historically, airborne contaminants of concern at Marathon have included mercury, particulate matter, and sulphur compounds from a bleached kraft pulp mill and adjacent chlor-alkali plant. Mercury emissions ceased when the chlor-alkali plant was closed in 1977. Fallout of particulate matter in the townsite was shown in several surveys to be negligible. At present, the Ministry maintains five air quality monitoring stations in Marathon (Figure 10) and one in Heron Bay.

Odour Levels

Table 14 shows that average sulphation levels have been stable since major mill modernization and pollution control programs were completed in 1978.

The Ministry's continuous TRS monitor at station 63034 collected valid data for 310 days in 1983. TRS concentrations exceeded the guideline 25 times during the year, and the maximum hourly average was 72 ppb, about 2½ times the guideline. To alert the mill when community odour levels above the desirable limit occur, the company will install, by the end of 1984, telemetry equipment to transmit TRS readings directly from our monitor to the mill.

Mercury in Surface Drainage Water and in Soil

For several years, the Ministry has sampled soil and surface drainage water near the chlor-alkali plant at the James River pulp mill. The chlor-alkali operation, which used a mercury-cell process, closed in 1977. Table 15 summarizes soil mercury levels at 10 sites (Figure 11(a)) from 1976 to 1983. The data show a decline in mercury concentrations in 1978 and 1980, but an unexpected increase, at some sites, in 1982 and 1983. The increased mercury at sites 6, 8, 9, 14 and 16 are attributed to airborne mercury releases during dismantling of equipment in the chlor-alkali plant in 1982 and 1983. At site 33, near the company's

warehouse, spillage of mercury-contaminated waste may have occurred. The reason for a rise in mercury in sub-surface soil at site 32 is unknown.

Although there is significant residual mercury contamination in soil near the mill, mercury in soil at sites off company property is normal, as our earlier reports have shown. Further, mercury in surface water draining the hillside near the former chlor-alkali plant (Figure 11(b)) was at or below the analytical detection limit. Therefore, there is no evidence of an environmental problem. The final dismantling of equipment in the old chlor-alkali plant will be completed in mid-1984, and mercury levels should decline permanently thereafter.

RED ROCK

In Red Rock, the Ministry operates a small air quality monitoring network near a kraft pulp mill to measure dustfall and odour levels in the townsite. The network comprises four dustfall jars and sulphation plates at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 12).

Particulate Matter

There was a substantial decline in average dustfall in 1983 compared to the three preceding years (Table 16). While two of the four sites still moderately exceeded the annual objective for total dustfall, the overall average for the townsite was down more than 40 percent. This decrease was due to a sharp decline in saltcake (down 55 percent) as a result of lower emissions from a new recovery furnace brought into operation in October, 1982. There was some evidence of improved dustfall in late 1982, but the real benefit of pollution controls showed up in 1983. Flyash, char particles, wood fibres and road dust contributed to the few elevated dustfall readings during the year.

A moss exposure study carried out during the summer also confirmed that airborne sodium was much lower in 1983, with the

new recovery furnace operating, than in 1977, when the old furnace was in use. A report on this survey is in preparation.

Odour Levels

As well as a decrease in dustfall in 1983, there was an improvement in odour levels. As Table 17 shows, average sulphation readings in 1983 declined about 50 percent from the average for the 1979-1982 period. Our TRS monitor confirmed the sulphation results. For 300 days of data, there were TRS concentrations above the guideline for only 98 hours compared with 317 hours for 292 days of data in 1982. The maximum hourly average, at 156 ppb, was less than half the highest concentration (339 ppb) recorded in 1982. The annual average, 1.8 ppb, was down 64 percent from the average of 5.0 ppb in 1982. Most of the elevated TRS readings occurred in May and June, when the company was experiencing operating problems at the mill. With these problems resolved, still further improvement in odour levels is expected in 1984.

TERRACE BAY

Previous surveys have shown that the kraft pulp mill in Terrace Bay does not cause fallout of particulate matter in the adjoining townsite. Therefore, the Ministry's monitoring program is directed toward measurement of odour levels in the townsite and at three points where an effluent ditch from the mill crosses the TransCanada Highway (Figure 13).

Odour Levels

Average sulphation rates in 1983 were similar to those recorded in 1982 (Table 18). None of the readings indicated a serious odour problem. As expected, the first crossing point of the effluent ditch at the highway (station 63094) had a higher average sulphation rate than the second and third crossing points downstream (stations 63095 and 63096).

During the 333 days of valid TRS data collection in 1983, there were 30 hourly readings above the provincial guideline of 27 ppb. The maximum hourly average was 102 ppb. Most of the high levels occurred during the summer. To alert the mill when pollutant concentrations are above desirable levels, Kimberly-Clark telemeters TRS data from the Ministry's monitor at St. Martin's School to the mill. The Ministry is currently negotiating with the company to secure further abatement of TRS emissions.

THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 14. In addition to a review of data from this network, the following discussion includes brief summaries of some special studies carried out in the Thunder Bay area in 1982.

Particulate Matter

Dustfall

Dust emitted from grain elevators was formerly a nuisance to Thunder Bay residents. Dustfall measurements near the elevators began in 1970, and the network has been revised periodically since then. The 1983 data for the 10 sites now monitored are summarized in Table 19. For the 10 months of the year for which data are available, dustfall exceeded the maximum acceptable limits at only two of the 10 sites. There was a high frequency of elevated dustfall readings at station 63046 (Can-Car, Montreal Street) and station 63047 (Totem Trailer Court). The principal contributor to dustfall at both sites was flyash. Emissions from coal-fired power boilers at Great Lakes Forest Products Limited were the source of this flyash fallout. Table 20 clearly shows the sharp rise in dustfall at the Trailer Court when regular use of coal began at Great Lakes in November, 1981. Thereafter, a

number of complaints were received of flyash fallout in residential areas around the Great Lakes mill. Table 20 also shows the sharp decline in dustfall recorded after collection equipment was installed in the mill's power boilers near the end of 1983.

Suspended Particulate Matter and Soiling Index

Total suspended particulate matter (TSP) was generally satisfactory throughout Thunder Bay in 1983 (Table 21). Only three percent of the total samples for all six monitoring sites slightly exceeded the 24-hour air quality objective of 120 $\mu g/m^3$. The annual objective was met at all locations. Filters from the two city-centre stations (63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, due to long-range transport, varied considerably. As noted in our 1982 report, many filters exposed during the winter had a distinct "smoky" aroma, caused by emissions from residential wood-burning. These emissions, at present, do not appear to be causing an air quality problem.

Because of equipment problems, no soiling index data are available for 1983. Soiling index levels in preceding years have been well within prescribed limits.

Gaseous Pollutants

Sulphur Dioxide (SO_2)

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt coal-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small, and total SO_2 emissions from all sources combined are less than 100 metric tons per day. The network of nine SO_2 monitors (seven belonging to Ontario Hydro and two owned by the Ministry) showed, with one exception, full compliance for all SO_2 air quality objectives in 1982 (Table 22). On April 18, Ontario Hydro's monitor on Mt. McKay recorded a 1-hour average

SO_2 concentration of 0.26 ppm, marginally above the 0.25 ppm objective. Wind data at the time of this occurrence implicate Great Lakes Forest Products Limited as the source of the SO_2.

Total Reduced Sulphur (TRS)

At the Montreal Street monitoring site (station 63046), the TRS guideline (27 ppb) was exceeded only three times during the year, the lowest exceedence frequency since monitoring began in 1977 (Table 23). The annual average was also the lowest yet recorded. In February, 1983, a new TRS monitor was installed at station 63046. Because this instrument is less responsive to most TRS compounds than the unit it replaced, average TRS concentrations reported by the new monitor would tend to be lower than before.

Ozone (O_3)

Ozone did not exceed the maximum acceptable limit (80 ppb) during 1983 at the Ministry's monitoring site (station 63040). The highest one-hour average, 71 ppb, was very similar to the maximum in preceding years. Highest readings were associated with southerly winds. Several studies have shown that ozone is a long-range transport pollutant whose primary sources are large urban and industrial centres.

Special Studies

Pulp Mills

Surveys again showed that no visible injury caused by sulphur dioxide or other pollutants was evident on vegetation near the three sulphite pulp mills in Thunder Bay.

Thunder Bay Terminals Limited

A report on 1983 air quality near Thunder Bay Terminals Limited (17) showed that this coal terminal continued to operate satisfactorily. There has been no increase in dust levels at off-property monitoring sites since coal shipments began in 1978.

Ontario Hydro - Thunder Bay Generating Station

A moss exposure study conducted during the spring of 1982 near Ontario Hydro's flyash disposal site revealed slightly elevated concentrations of some elements immediately adjacent to the disposal area (18). The elements examined showed no off-property contamination.

Hawkeye Lake Acid Rain Study Site

Lakehead University, on contract to the Ministry, is conducting a long-term study of acid rain in northwestern Ontario. Most of the terrestrial effects work is carried out in a 95-hectare watershed near Hawkeye Lake, about 40 kilometres north-northwest of Thunder Bay. At this site, sulphur dioxide, nitrogen oxides and ozone are continuously monitored. From June, 1983, when air quality monitoring began, to the end of the year, sulphur dioxide and nitrogen oxide levels met all air quality objectives and were only occasionally above the detection limit (about 5 ppb). The maximum ozone reading was 79 ppb, just below the acceptable limit of 80 ppb. The results of other investigations at Hawkeye Lake will be reported separately.

ACKNOWLEDGEMENTS

The assistance of staff of the following agencies is gratefully acknowledged: Atmospheric Environment Service, Atikokan Weather Station, for operating a high-volume sampler; Dingwall Medical Clinic, Dryden, for assistance in operating our TRS monitor; and Ontario Hydro for data from its SO_2 monitoring network in Thunder Bay.

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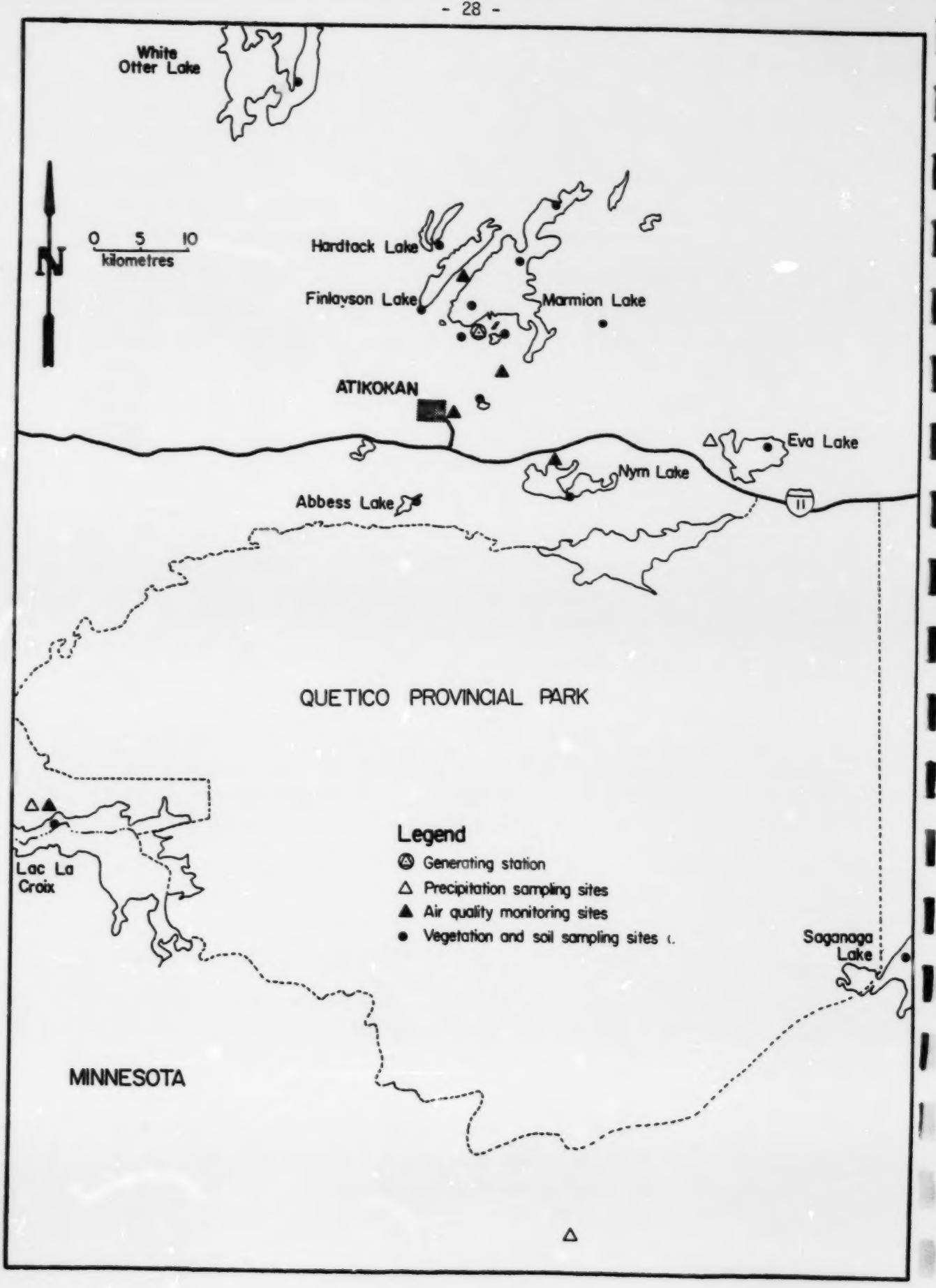


Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

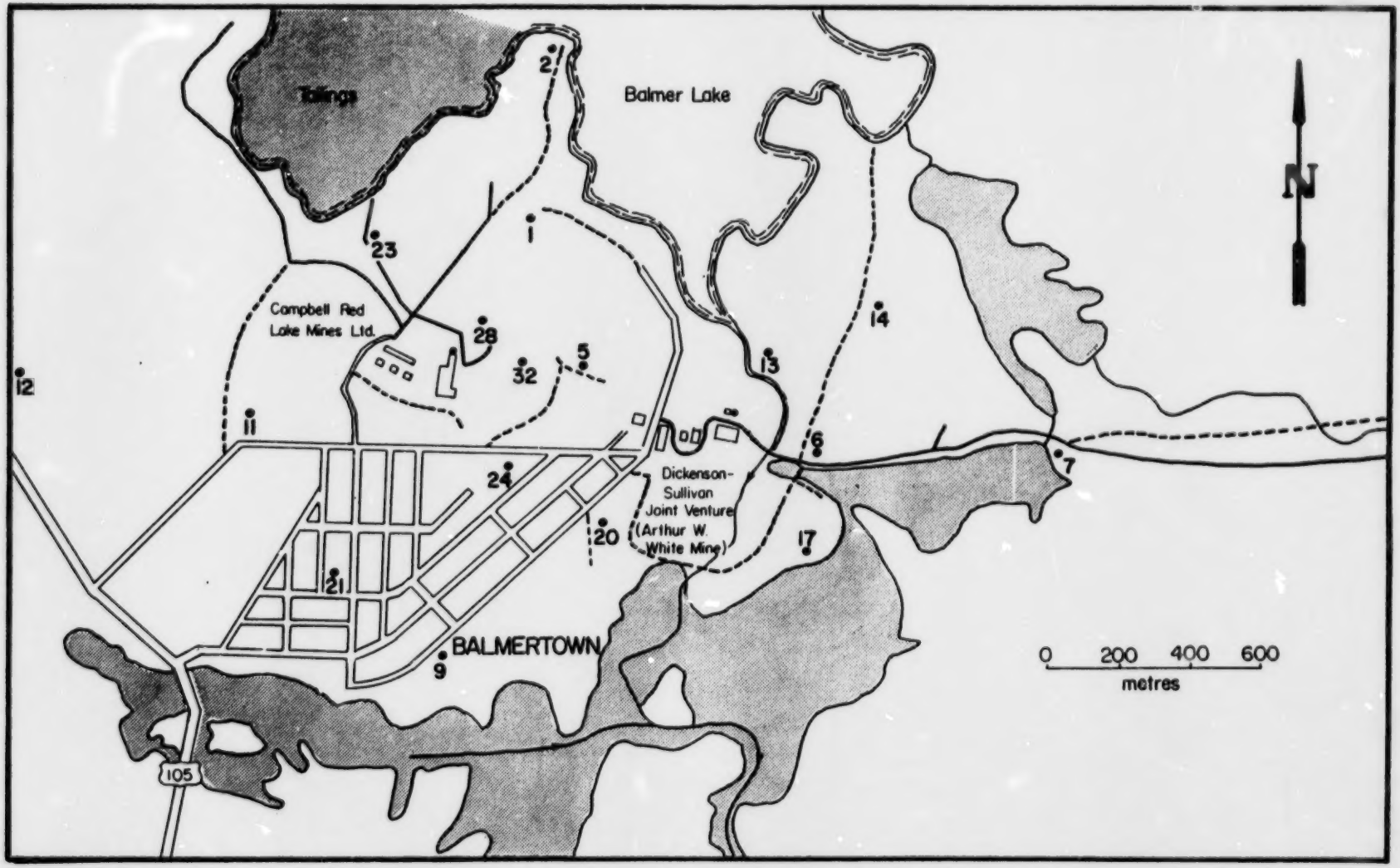


Figure 2. Trembling aspen sampling sites, Balmertown, 1983.

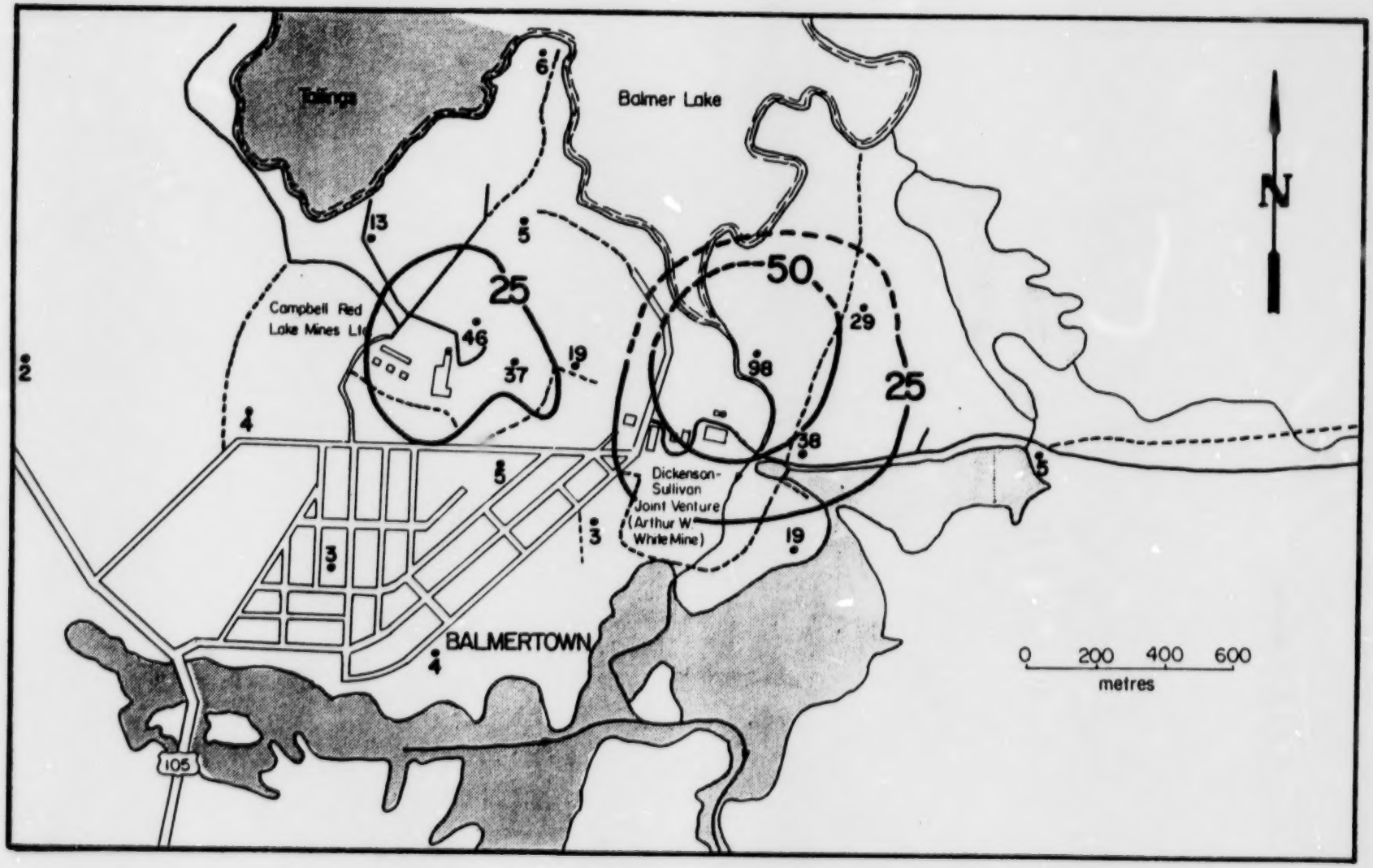


Figure 3. Arsenic (µg/g, dry weight) in trembling aspen leaves, Balmertown, August, 1983.

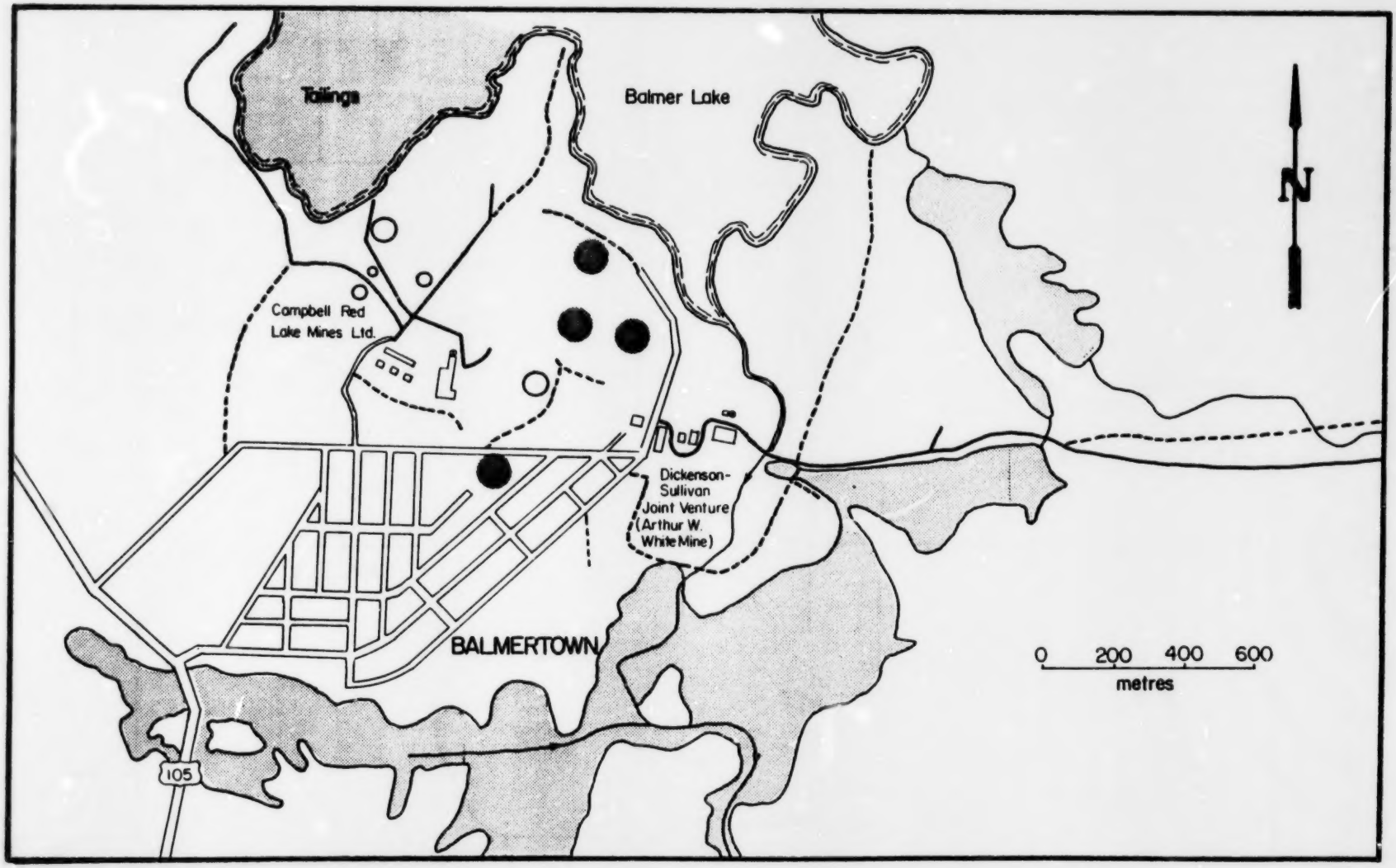


Figure 4. Sulphur dioxide injury to vegetation, Balmertown, August, 1983.

Confirmed damage
Possible damage

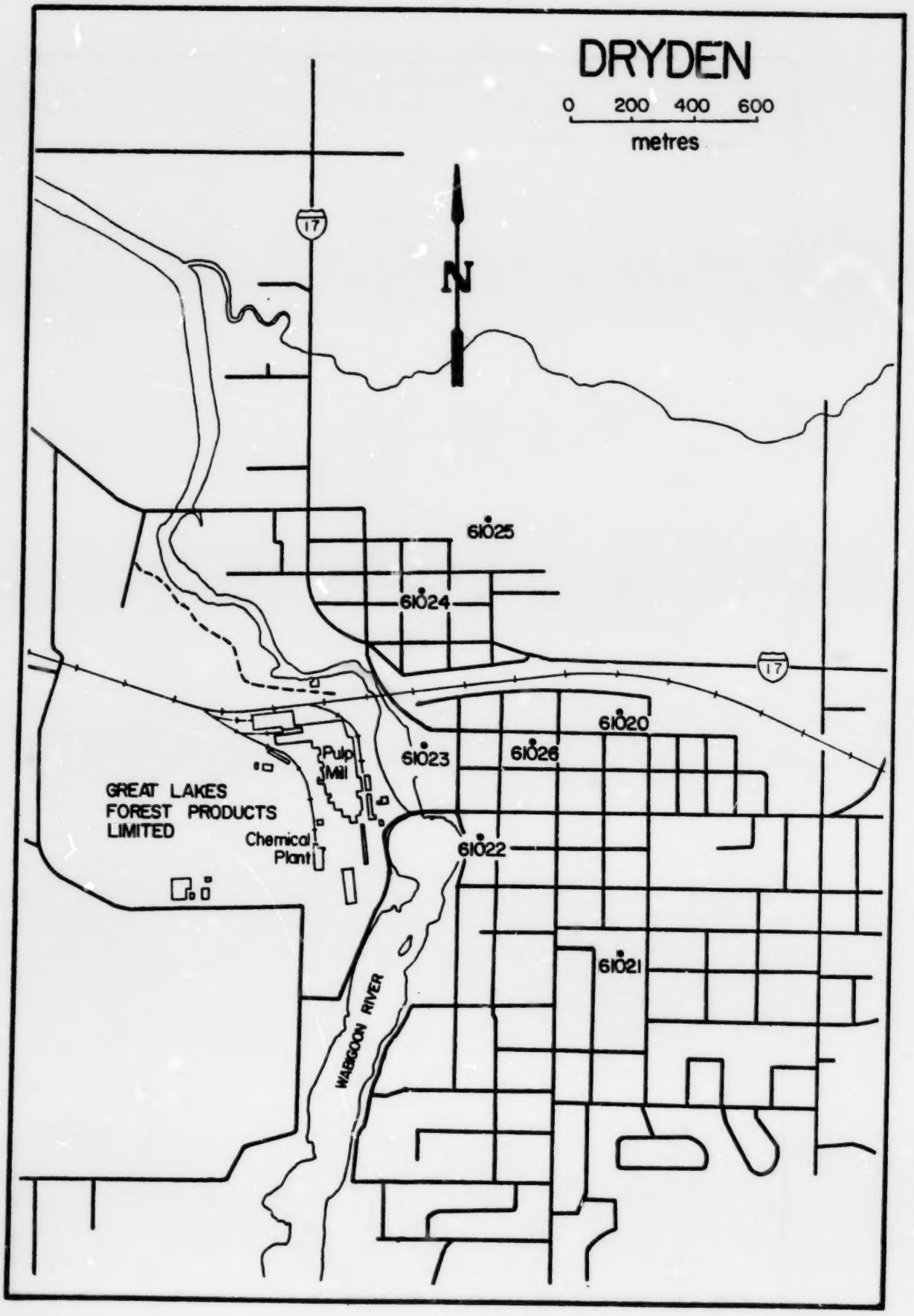


Figure 5 . Air quality monitoring sites, Dryden, 1983. (TRS only at 61026)

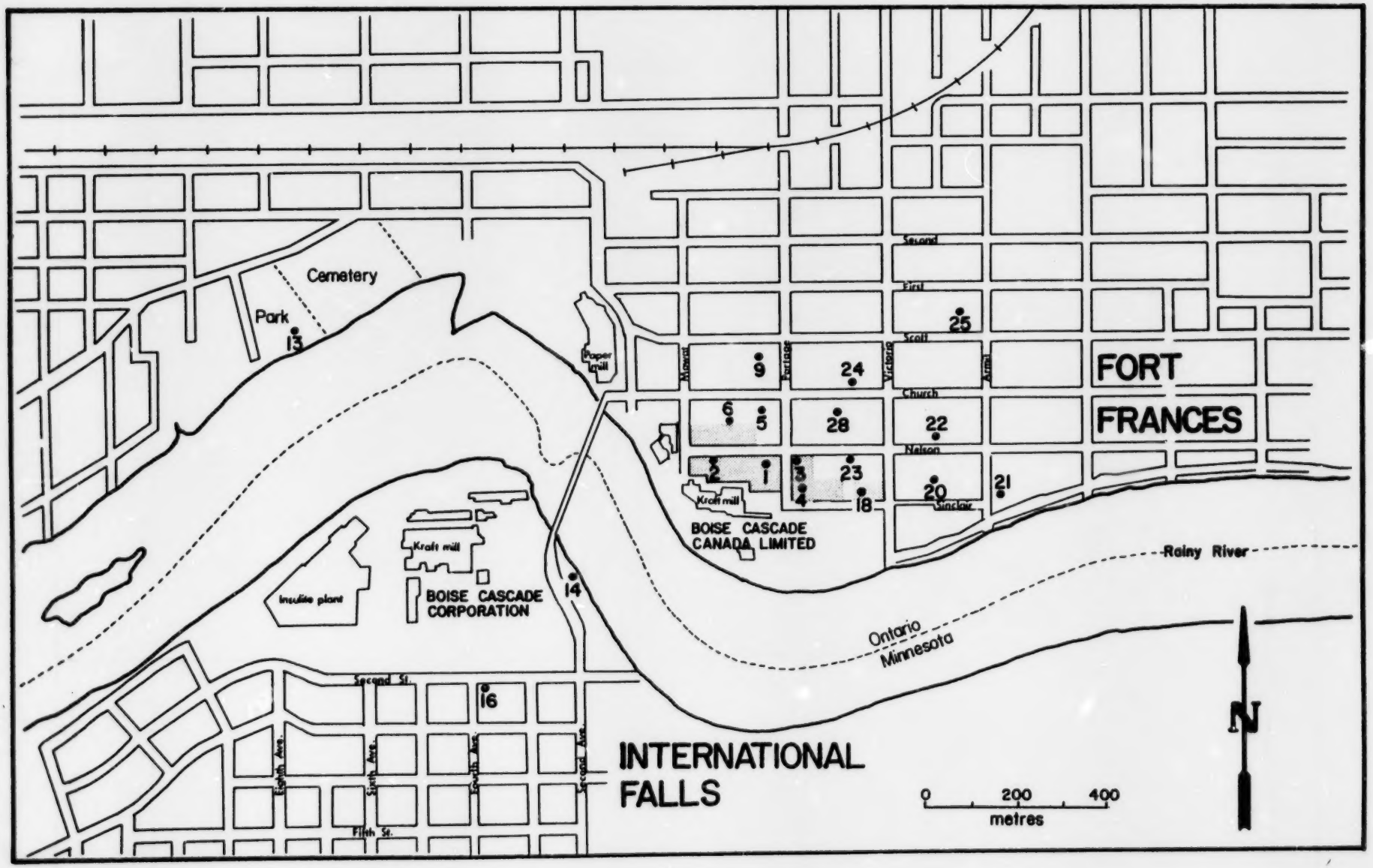


Figure 6. Manitoba maple sampling sites, Fort Frances, August, 1983

Buffer zone

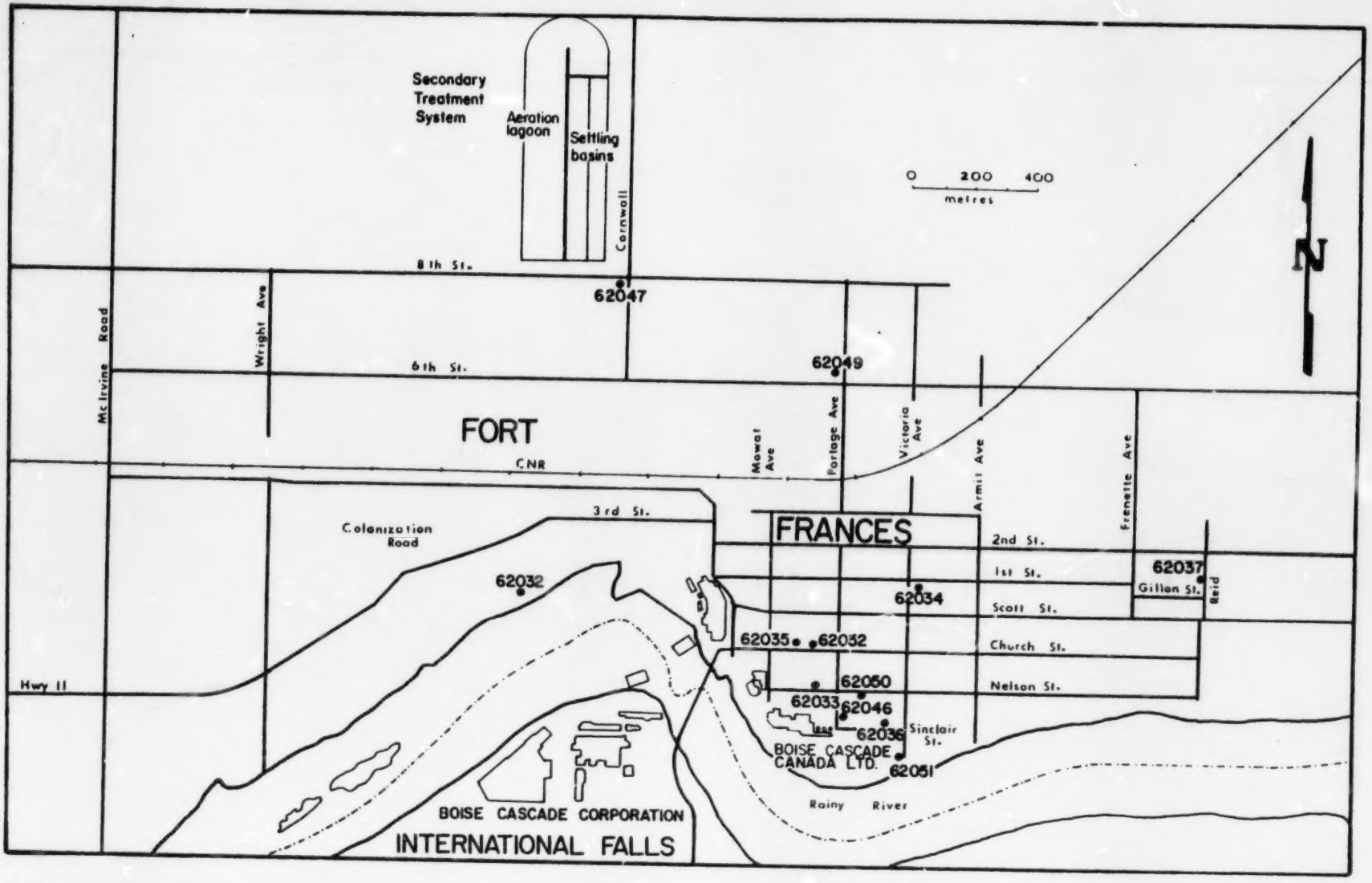


Figure 7. Air quality monitoring sites, Fort Frances, 1983.

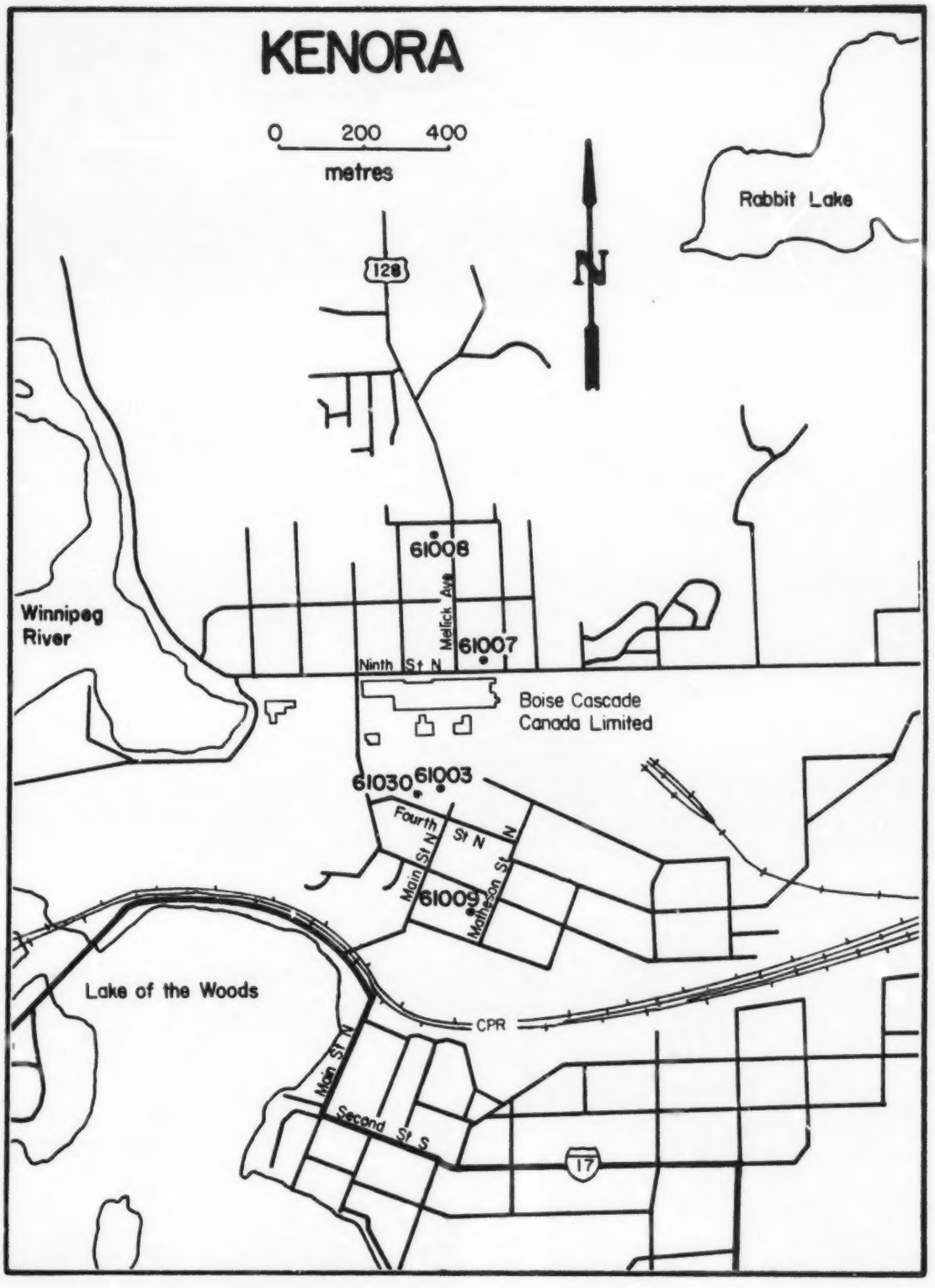


Figure 8. Air quality monitoring sites, Kenora, 1983 (SO_2 only at station 61030).

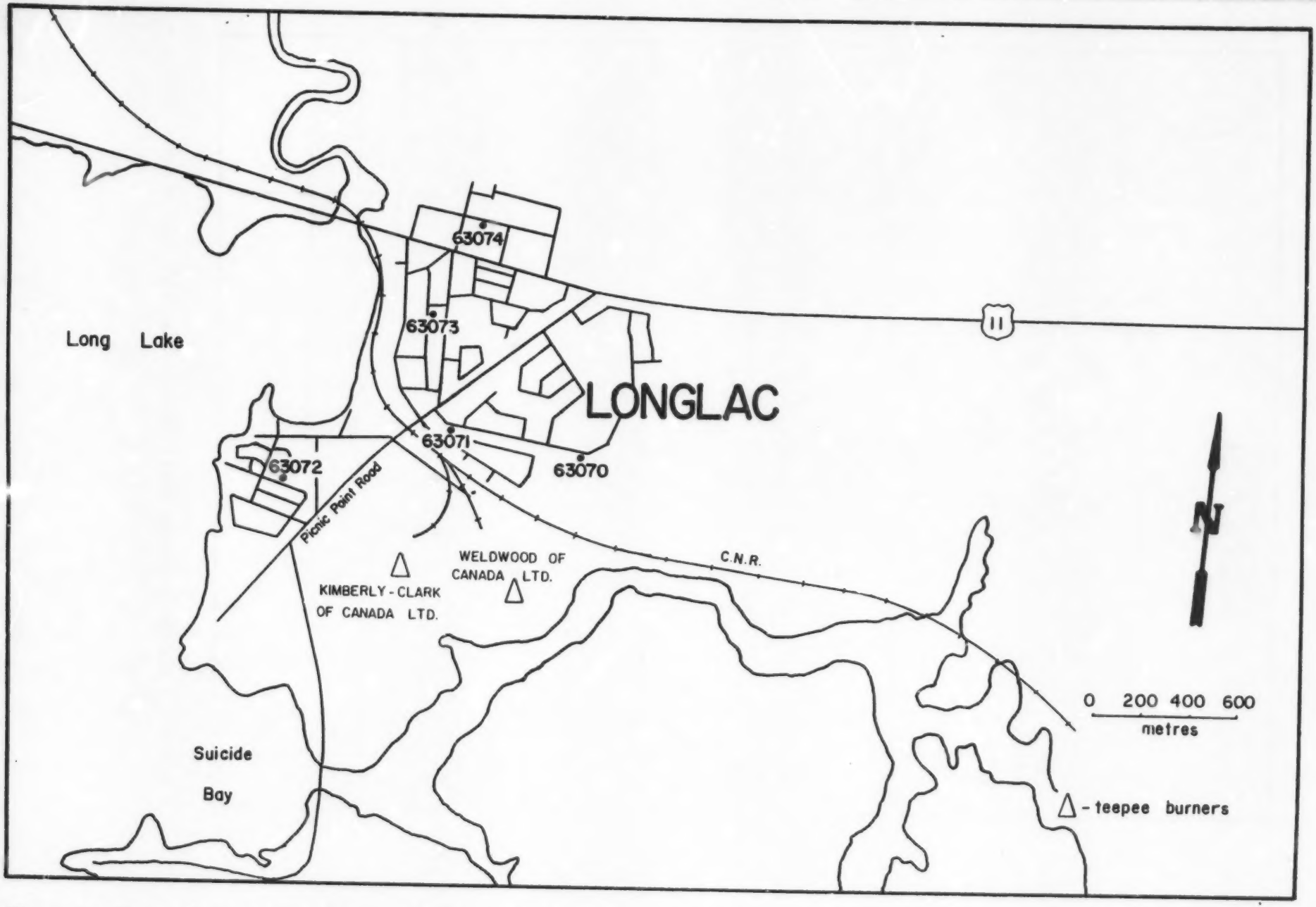


Figure 9. Air quality monitoring sites, Longlac, 1983.

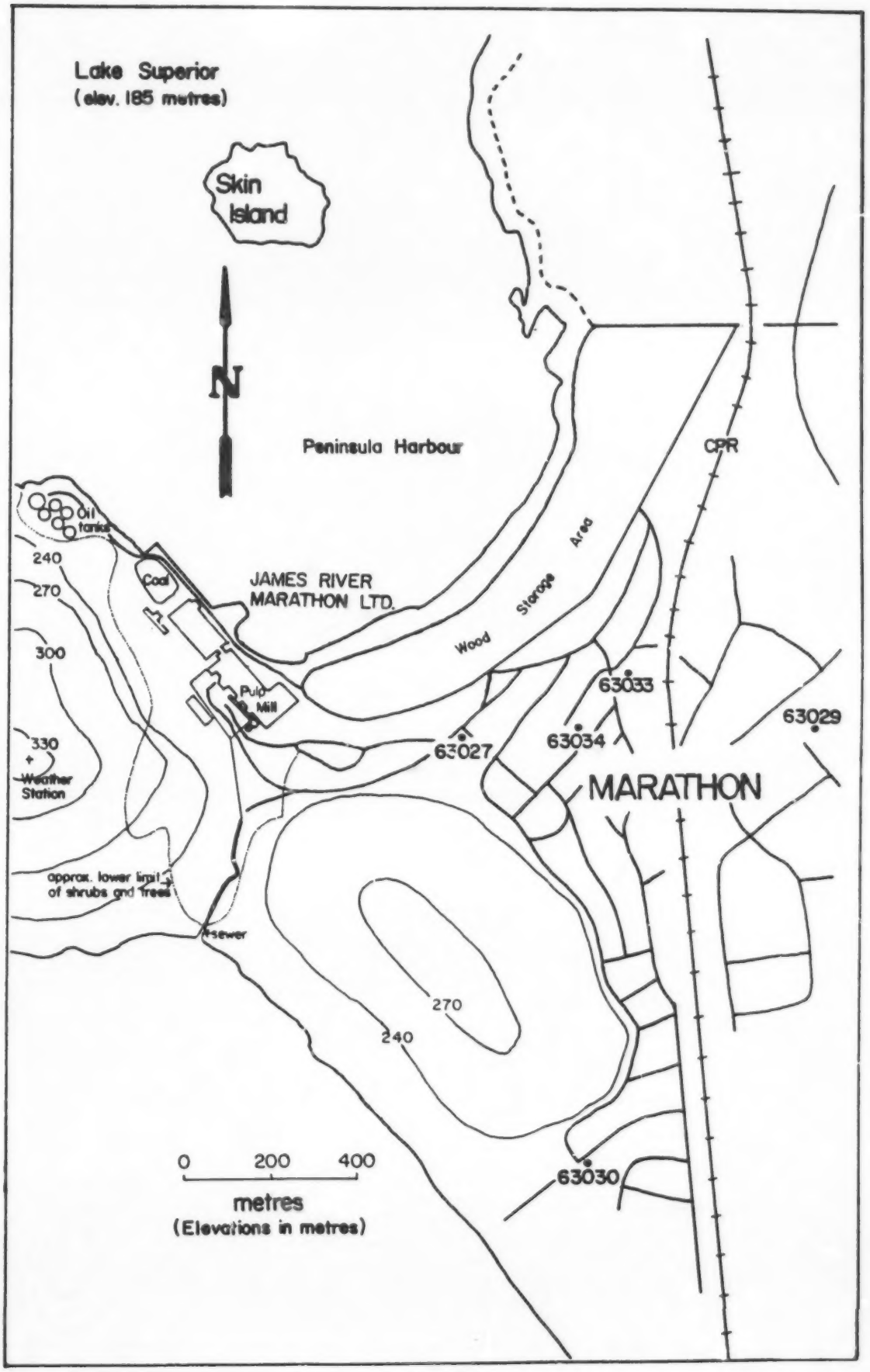


Figure 10. Air quality monitoring sites, Marathon, 1983 (except station 63032, Heron Bay).

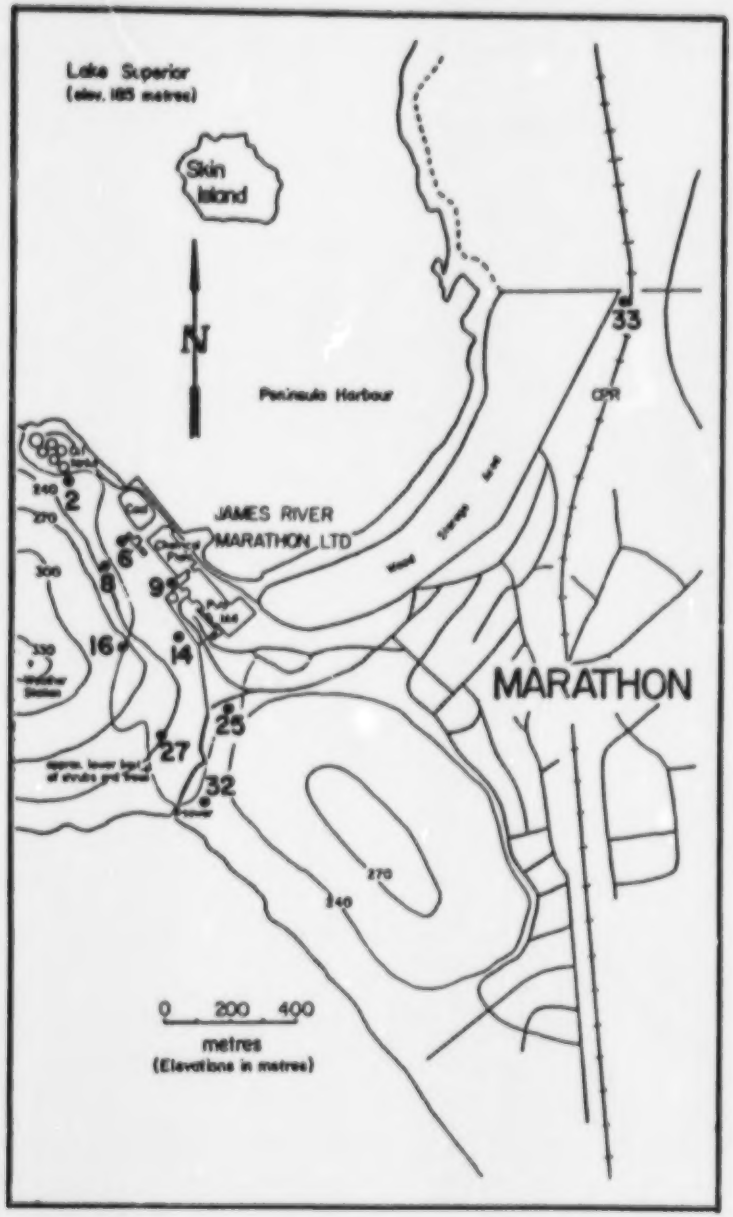


Figure IIa. Soil sampling sites, Marathon, 1983.

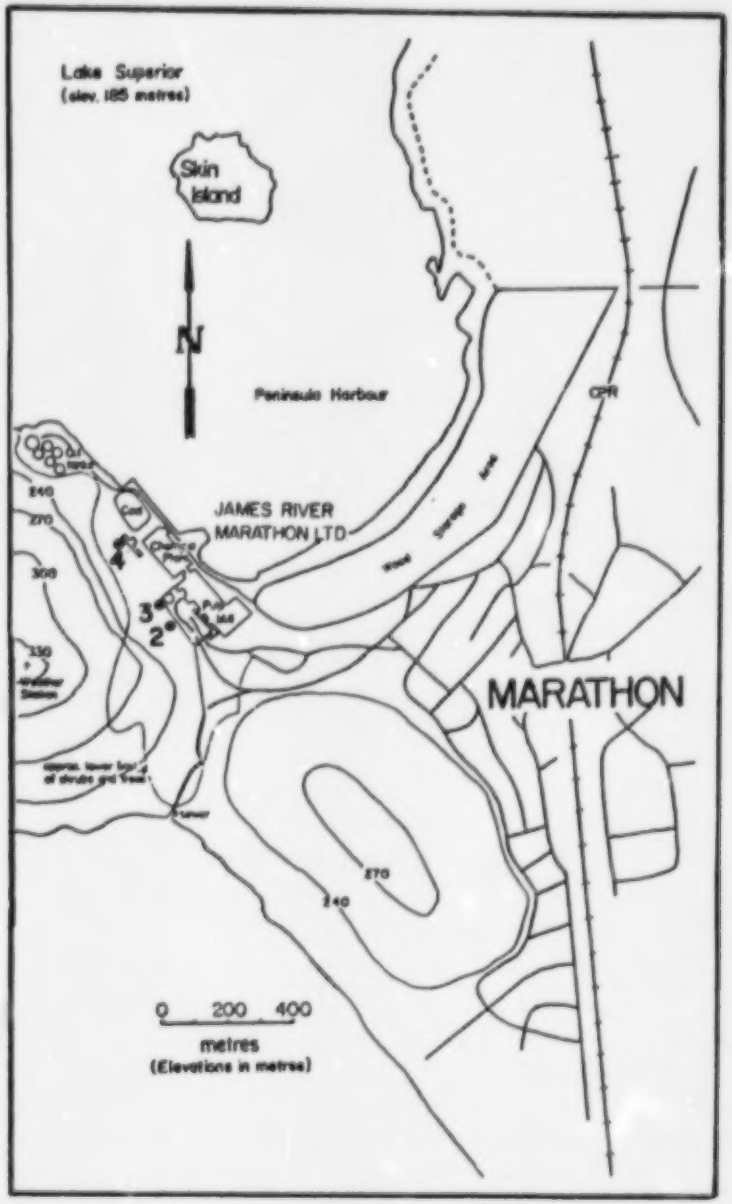


Figure IIb. Surface drainage-water sampling sites, Marathon, 1983.

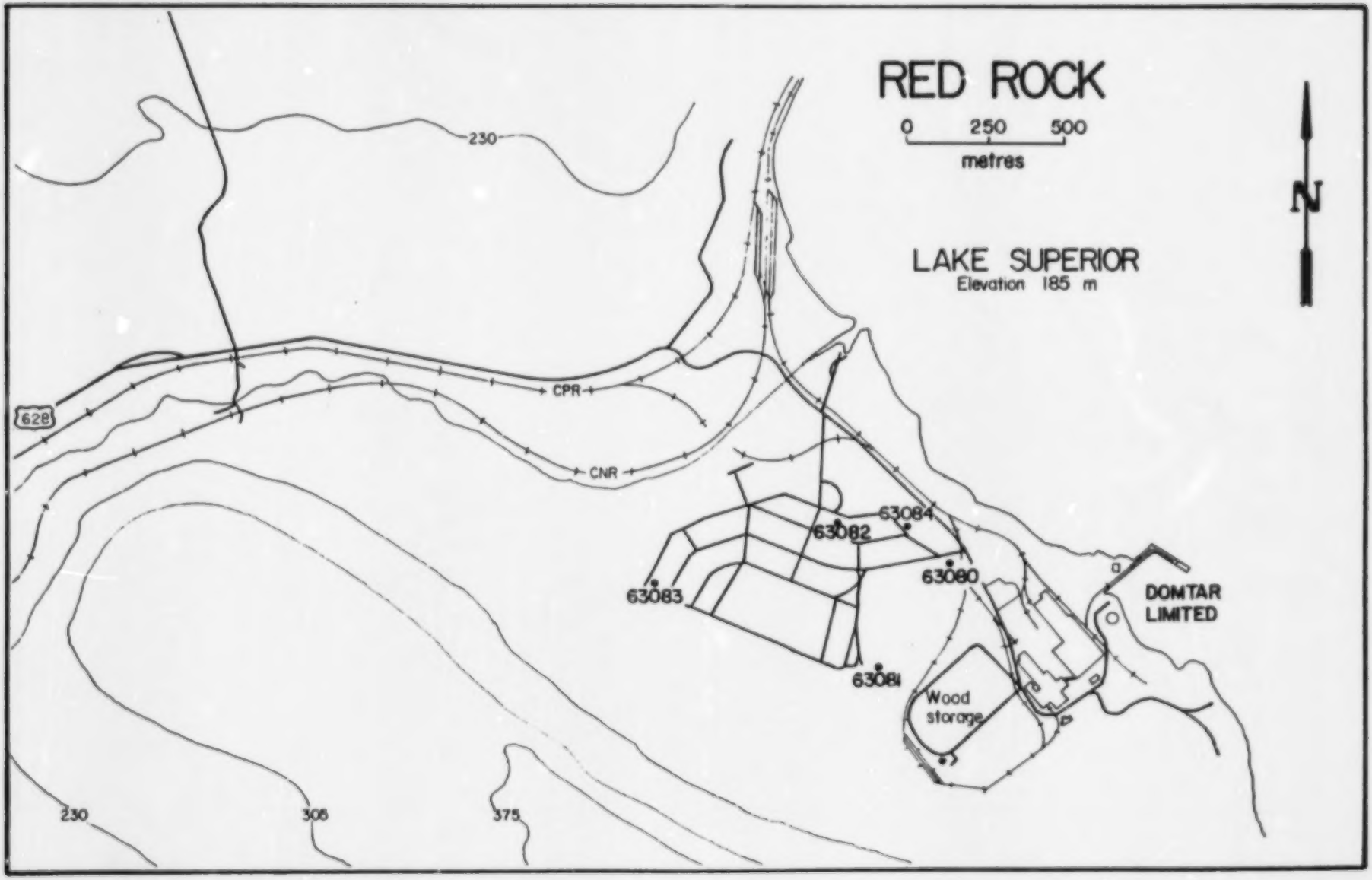
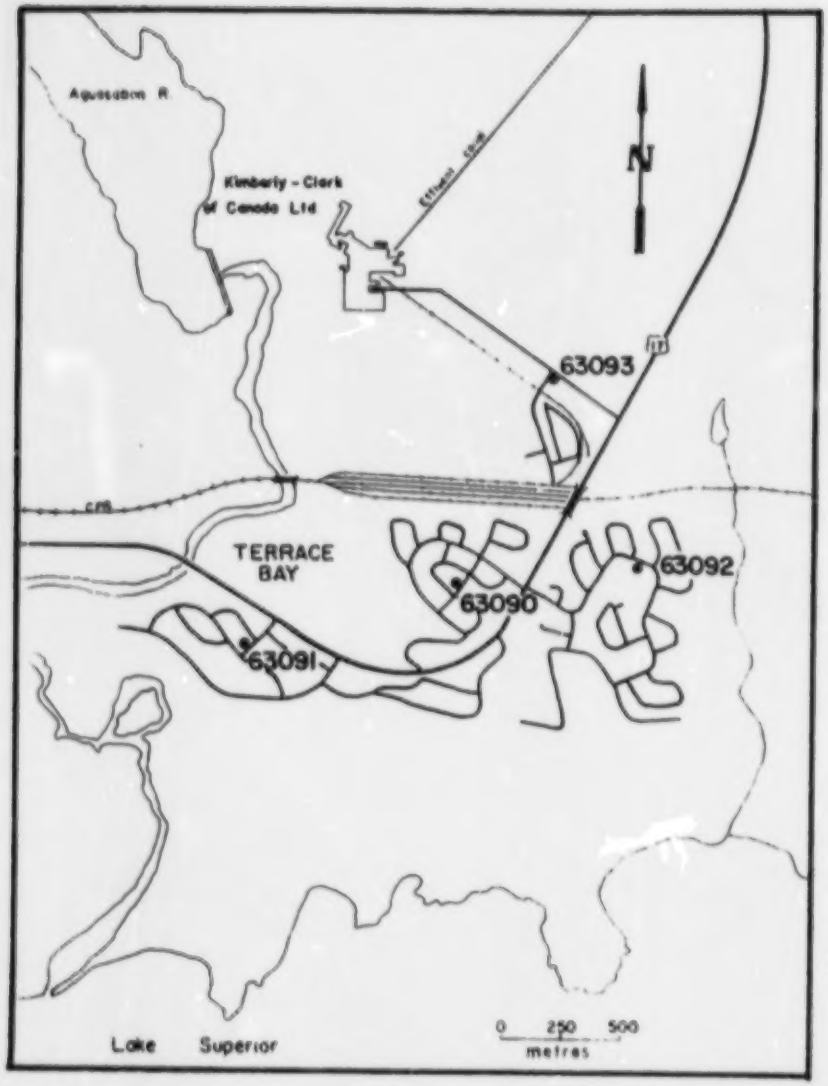


Figure 12. Air quality monitoring sites, Red Rock, 1983



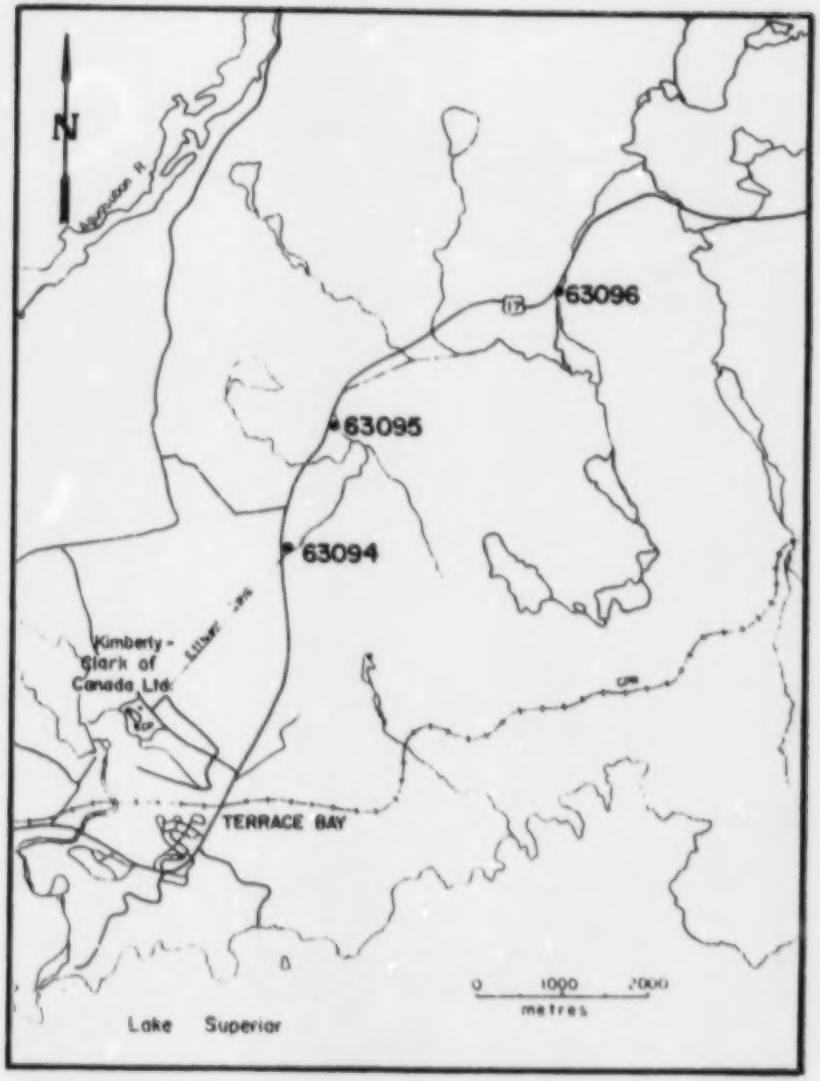


Figure 13. Air quality monitoring sites, Terrace Bay, 1983.

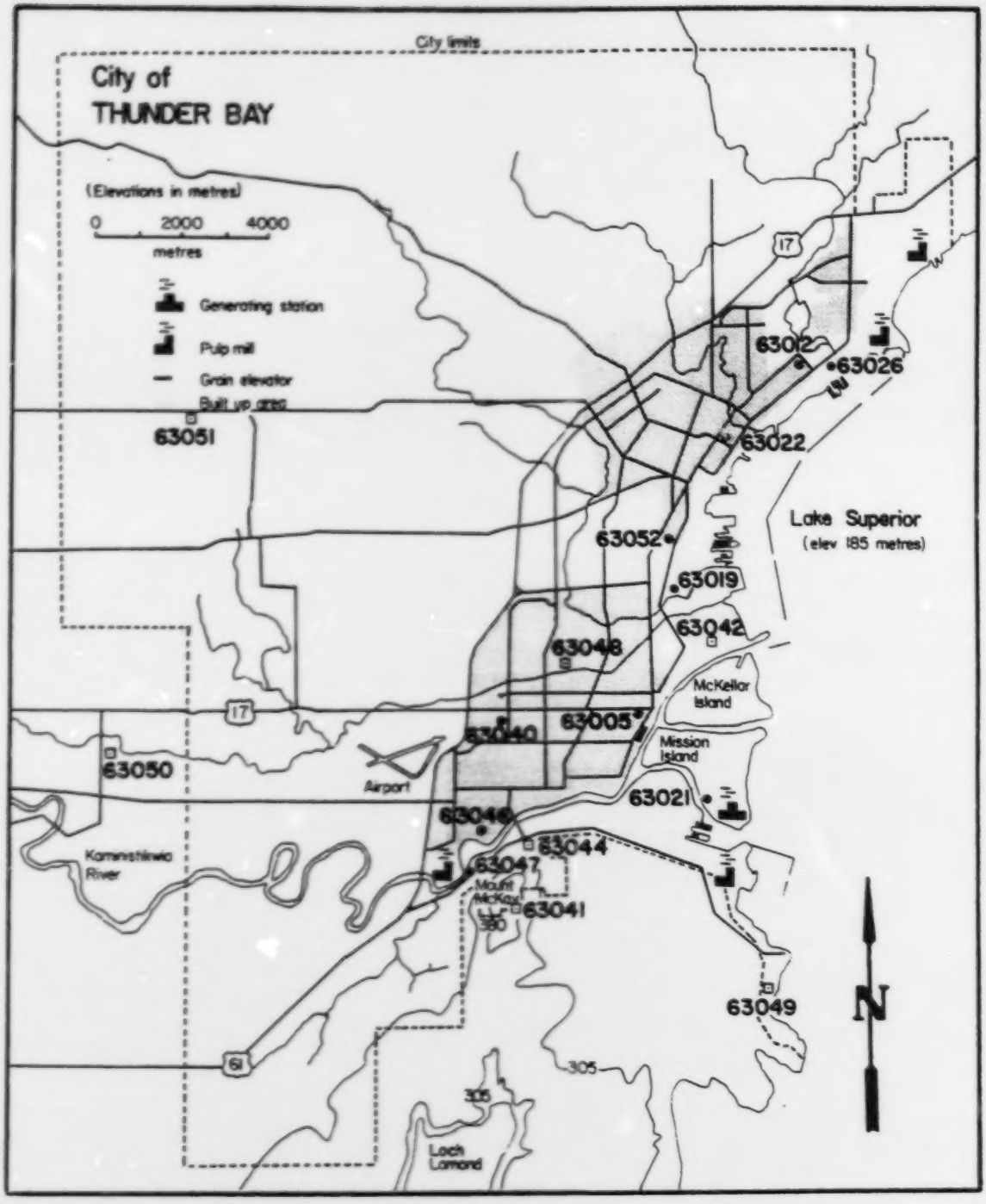


Figure 14. Air quality monitoring sites, Thunder Bay, 1983.
(□ Ontario Hydro sites)

TABLE 1. Arsenic content (µg/g, dry weight) of unwashed trembling aspen foliage near Balmertown, 1972 to 1983.

Site[a]	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1			26[b]	31	10	5	4	3	6	5	9	5
2			22	26	6	12	9	3	6	4	12	6
5	160	550	29	33	18	12	9	22	28	6	60	19
6	78	400	200	260	50	8	33	11	55	63	36	38
7	21	81	43	29	5	4	20	4	4	2	5	5
8			14	18	4	2	6	2	2	1		
9	260	410	19	6	6	5	5	9	3	5	5	4
11	98	110	10	7	2	4	2	5	3	4	6	4
12	27	41	9	9	4	3	3	6	1	2	13	2
Controls	<1	8	3	2	<1	<1	<1	<1	<1	<1	<1	<1

[a]Shown in Figure 2.

[b]Values above proposed contaminant guideline (2 µg/g) are underlined.

TABLE 2. Average arsenic content (µg/g, dry weight)[a] of unwashed foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1973 to 1983.

Year	Side of tree[b]	Dickenson & Mine Road	Balmertown public school	Fifth St. & Mine Road	Controls
1973	Facing	504[c]	734	352	19
	Away	323	432	202	25
1974	Facing	70	36	20	4
	Away	31	21	12	
1975	Facing	138	76	34	4
	Away	58	46	18	
1976	Facing	18	12	20	2
	Away	18	9	11	
1977	Facing	13	6	8	<1
	Away	16	5	8	
1978	Facing	5	5	5	<1
	Away	4	4	3	
1979	Facing	69		8	2
	Away	22		7	
1980	Facing	7	5	6	1
	Away	5	5	3	
1981	Facing	11	7	8	<1
	Away	12	7	5	
1982	Facing	14	8	10	<1
1983	Facing	18	7	-	<1

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Facing and away from gold mines.

[c]Values above proposed contaminant guideline (2 µg/g) are underlined.

TABLE 3. Average arsenic levels[a] (µg/g, dry weight) in washed vegetables and surface soil (0-5 cm) from three Balmertown gardens, 1973-1983.

Sample	1973	1975	1977	1979	1981	1983
			Balmertown			
Potato leaves[c]		24	9	37	8	8
Potato tubers		2	<1	<1	<1	1
Beet leaves	180[d]	8	7	13	2	5
Beet roots	40	9	6	8	<1	5
Lettuce leaves	140	18	7	12	6	8
Garden soil		150	360	93	75	100
Lawn soil		450	340	270	320	330
			Red Lake (control)			
Potato leaves[c]		2	2	5	<1	2
Potato tubers		<1	<1	<1	<1	<1
Beet leaves	3	<1	<1	<1	<1	<1
Beet roots	2	<1	<1	<1	<1	<1
Lettuce leaves		<1	<1	1	2	<1
Garden soil		10	7	6	3	8
Lawn soil		10	8	24	7	15

[a]Values for 1975 to 1979 are averages of triplicate samples. Those for other years represent single samples.

[b]Two gardens 1979.

[c]Unwashed.

[d]Values above proposed contaminant guidelines (2 µg/g for vegetation, 10 µg/g for soil) are underlined.

TABLE 4. Average annual dustfall (gm/m²/30 d), Dryden, 1976 to 1983.

Year	Station 61020	61021	61022	61023	61024	61025	All stations
1976	8.0[a]	6.3	9.8	11.5	5.9	4.5	7.7
1977	5.8	7.7	7.4	8.5	6.0	3.2	6.4
1978	4.7	5.1	6.0	4.6	2.9	2.5	4.3
1979	3.9	4.7	3.2	5.3	2.8	2.7	3.8
1980	3.2	3.8	4.6	5.2	3.8	3.9	4.1
1981	4.0	4.3	4.1	5.6	3.9	4.4	4.4
1982	3.8	4.4	4.8	5.4	3.8	4.2	4.4
1983	3.7	1.8	3.6	2.6	2.9	3.1	3.0

[a]Values exceeding maximum acceptable limit of 4.6 g/m²/30 days are underlined.

TABLE 5. Average annual sulphation rates (mg SO_3/100 cm²/d), Dryden, 1977 to 1983.

Station	Location	1977	1978	1979	1980	1981	1982	1983
61021	Casimir/St. Charles	0.16	0.20	0.14	0.16	0.09	0.06	<0.05
61023	King/Wabigoon	0.34	0.43	0.44	0.35	0.18	0.11	0.09
61025	Park/Second	0.13	0.12	0.14	0.12	0.10	0.05	<0.05
61026	56 King Street		0.20	0.23	0.18	0.14	0.07	0.05
	Average		0.24	0.24	0.20	0.13	0.07	0.05

TABLE 6. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1977-1983.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1977	325	3.7	164	270
1978	282	6.7	479	400
1979	200	8.7	236	391
1980	275	6.1	436	476
1981	279	5.5	190	405
1982	312	2.1	139	153
1983	257	1.5	121	68

TABLE 7. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1980-1983.

Site[a]	Chloride (%, dry weight)				Sodium (µg/g, dry weight)			
	1980	1981	1982	1983	1980	1981	1982	1983
1	1.20	0.62	0.26	0.40	1800[b]	2090	560	1000
2	0.81	0.43	0.30	0.36	1400	2200	1900	1900
3	0.87	0.40	0.21	0.26	1200	710	120	210
4	0.71	0.22	0.21	0.24	620	330	190	340
5	0.35	0.22	0.13	0.23	260	330	160	670
6	0.36	0.38	0.21	0.34	390	800	770	1800
9	0.22	0.18	0.22	0.16	150	130	86	430
13	0.04	0.04	0.03	0.04	83	72	110	210
14	0.08	0.08	0.13	0.08	53	126	230	470
16	0.53	0.16	0.41	0.12	73	69	88	160
18	0.21	0.11	0.10	0.12	120	60	38	65
20	0.10	0.09	0.08	0.09	250	140	120	160
21	0.15	0.11	0.14	0.14	250	70	48	<25
22	0.13	0.12	0.11	0.13	240	100	120	63
23	0.26	0.12	0.06	0.10	280	100	57	98
24	0.42	0.24	0.22	0.22	210	150	99	83
25	0.17	0.20	0.11	0.10	410	230	120	96
28			0.16	0.14			70	110
Controls	0.10	0.08	0.07	0.06	100	56	65	<25

[a] See Figure 6 for station locations.

[b] Values above proposed contaminant guidelines (350 µg/g for sodium and 0.85 for chloride) in vegetation are underlined.

TABLE 8. Average annual dustfall (g/m²/30 d), Fort Frances, 1983.

Monitoring station	Total dustfall	Insoluble dustfall	Saltcake in dustfall
62032	3.6	2.9	0.6
62033	9.2[a]	4.8	2.4
62034	9.8	3.4	0.8
62035	7.4	5.2	1.6
62036	9.0	6.0	1.4
62037	4.0	1.7	0.7
62046	9.4	6.0	1.3
62050	7.1	5.7	1.0
Averages	7.4	4.5	1.2
% of total dustfall		61	16

[a]Values above maximum acceptable limit (4.6 g/m²/30 d) are underlined.

TABLE 9. Average annual dustfall (g/m²/30 d) at six Fort Frances monitoring sites[a], 1979-1983. Percentages of total dustfall are shown in parentheses.

Parameter	1979	1980	1981	1982	1983
Total dustfall	8.7	7.0	7.6	7.2	7.5
Insoluble dustfall	4.0 (46)	3.9 (56)	4.4 (58)	4.0 (56)	4.1 (55)
Saltcake in dustfall	2.1 (24)	1.2 (17)	1.2 (16)	1.3 (18)	1.2 (16)

[a]Stations 62032, 62033, 62034, 62036, 62037 and 62046.

TABLE 10. Average annual sulphation rates (mg SO_3/100 cm^2/d), Fort Frances, 1979-1983.

Station	Location	1979	1980	1981	1982	1983
62032	Cemetery	0.13	0.09	0.05	0.06	0.08
62033	Nelson/Portage	0.40	0.27	0.24	0.20	0.19
62034	First/Victoria	0.13	0.09	0.05	0.05	0.06
62036	Sinclair/Victoria	0.13	0.09	0.06	0.06	0.06
62037	Reid/Gillon	0.09	0.09	0.05	<0.05	0.05
62046	Sinclair/Portage	0.23	0.12	0.11	0.10	0.09
	Averages	0.18	0.12	0.09	0.08	0.09

TABLE 11. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052, 62032 and 62051, Fort Frances, 1976-1983.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 62030		
1976	309	12.8	458	916
1977	294	15.4	480	969
1978	304	16.1	540	1035
1979	344	10.2	353	911
1980	352	9.3	499	872
1981	277	12.0	279	806
1982	320	8.8	543	685
1983[a]	336	4.9	254	418
		Station 62032		
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
		Station 62051		
1983	349	4.3	161	345

[a]Station 62052.

TABLE 12. Average annual dustfall (g/m²/30 d), Kenora, 1980-1983.

Station	Location	1980	1981	1982	1983
61003	Fourth/Main	4.1	4.7[a]	3.1	2.5
61007	Melick/Ninth	10.7	14.1	10.0	7.0
61008	Melick/Eleventh	3.7	4.1	2.7	2.5
61009	Third/Matheson	5.6	7.1	4.5	3.3
	Averages	6.0	7.5	5.1	3.8

[a]Values exceeding maximum acceptable levels of 4.6 are underlined.

TABLE 13. Average annual sulphation rates (mg SO_3/100 cm²/d), Kenora, 1980-1982.

Station	Location	1980	1981	1982	1983
61003	Fourth/Main	0.16	0.11	0.07	0.06
61007	Melick/Ninth	0.16	0.21	0.10	0.10
61008	Melick/Eleventh	0.13	0.18	0.15	0.20
61009	Third/Matheson	0.06	0.07	0.05	<0.05
	Averages	0.13	0.14	0.09	0.10

TABLE 14. Average annual sulphation rates (mg SO_3/100 cm²/d), Marathon, 1976 to 1983.

Station	Location	1979	1980	1981	1982	1983
63027	McLeod/Abrams	0.15	0.12	0.10	0.18	0.19
53029	Marathon Shell	0.17	0.09	0.09	0.11	0.13
63030	Howe/Yawkey	0.15	0.11	0.11	0.11	0.12
63032	Heron Bay	0.10	0.06	0.07	0.08	0.06
63033	Water Tower	0.16	0.16	0.15	0.15	0.21
	Averages	0.15	0.12	0.10	0.13	0.14

TABLE 15. Mercury (µg/g, dry weight) in soil sampled between 1976 and 1983 on James River Marathon Limited property.

Site[a]	Soil Depth														
	0-5 cm					5-10 cm					10-15 cm				
	1976	1978	1980	1982	1983	1976	1978	1980	1982	1983	1976	1978	1980	1982	1983
2	4	5	3	4	3	3	2	3	5	6	3		2	4	4
6	14	18	4	28	22	11	2	0.3	22	10	6	4	0.4	10	3
8	3	5	4	15	6	5	0.8	8	13	3	0.8		7	3	2
9	36	58	45	55	89	32	13	10	44	45	21	3	2	30	14
14	18	12	5	10	3	14	4	1	13	3	13	2	<1	5	2
16	3	3	3	10	9	2	0.4	0.8	3	9	0.4	0.1	0.8	0.5	3
25	2	2	2	2	1	1	0.5	0.6	0.9	0.2	0.6	0.2	0.5	0.4	0.1
27	1	1	3	4	5	0.9	0.4	2	2	2	0.5	0.4	0.4	0.4	1
32	48	43	21	49	31	22	16	4	48	31	6	4	2	39	36
33	12	7	15	77	63			2	12	2			0.9	2	1
Controls	<0.1	<0.1	<0.1	0.2	0.3	<0.1	<0.1	<0.1	0.2	0.2	<0.1	<0.1	<0.1	<0.1	<0.1

[a]See Figure 11(a).

[b]Values exceeding proposed contaminant guideline (0.2 µg/g) are underlined.

TABLE 16. Average annual dustfall (g/m²/30 d), Red Rock, 1980-1983.

Station[a]	1980-81			1982			1983		
	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake	Total	Insoluble	Saltcake
63080	8.9[b]	3.6	2.6	9.8	5.0	2.8	5.9	3.9	1.2
63081	6.4	2.9	1.6	4.0	1.8	1.2	4.3	2.4	0.5
63082	13.6	3.4	7.2	9.9	2.4	7.1	6.0	2.4	2.1
63083	3.4	1.4	1.0	2.6	1.2	0.9	2.0	1.0	0.3
Average	8.1	2.8	3.1	7.9	2.6	3.0	4.6	2.4	1.4

[a]See Figure 12 for station locations.

[b]Values exceeding annual objective of 4.6 g/m²/30days are underlined.

TABLE 17. Average annual sulphation rates (mg SO_3/100 cm^2/d), Red Rock, 1979-1983.

Station	Location	1979	1980	1981	1982	1983
63080	Rankin Street	0.58	0.66	0.46	0.50	0.31
63081	Stewart/Frost	0.13	0.15	0.15	0.11	0.10
63082	47 Timmins Street	0.24	0.27	0.27	0.21	0.10
63083	122 Brompton Road	0.09	0.13	0.11	0.08	<0.05
	Averages	0.26	0.30	0.25	0.22	0.13

TABLE 18. Average annual sulphation rates (mg/SO_3/100 cm^2/d), Terrace Bay, 1982-1983.

Station	Location	1982	1983
63090	St. Martin School	0.15	0.14
63091	Ft. Garry Road	0.10	0.14
63092	Terrace Heights Dr.	0.10	0.07
63093	Mill Road	0.10	0.08
63094	Highway 17, #1	0.10	0.14
63095	Highway 17, #2	0.08	0.08
63096	Highway 17, #3	0.04	0.06

TABLE 19. Total dustfall (g/m²/30 d) and average pH of dustfail solutions, Thunder Bay, 1983.

Station	Location	Monthly Min	Monthly Max	Annual average	pH
63005	McKellar Hospital	1.5	6.5	3.1	4.6
63012	Dawson Court	1.3	3.7	2.6	4.9
63019	Main St. Pumping Station	1.3	4.3	2.7	5.1
63021	Mission Island	0.4	3.1	1.7	4.4
63022	St. Joseph's Hospital	1.6	2.7	2.7	4.7
63026	N. Cumberland Hydro	1.4	4.0	2.4	4.9
63040	435 James St. South	1.0	5.2	3.0	4.3
63046	Montreal Street	6.2	12.9[b]	9.9	7.8
63047	Totem Trailer Court	6.5	16.6	12.6	6.1
63052	Thunder Bay Transit	1.0	5.1	2.8	4.5

[a]No data for May and June.

[b]Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 20. Total dustfall (g/m²/30 d) at Totem Trailer Court (station 63047), during winter months from 1978 to 1984.

Year	Nov	Dec	Jan	Feb	Mar	Mean
1978-79	1.5	1.5	2.8	0.1	3.0	1.8
1979-80	6.7	1.8	2.7	4.8	5.2	4.2
1980-81	3.0	2.9	1.8	5.2	4.9	3.6
1981-82	10.1[a]	12.7	8.7	9.8	12.6	10.8
1982-83	17.5	15.1	16.6	16.0	9.8	15.0
1983-84	9.1	6.5	9.9	3.1	6.9	7.1

[a]Values exceeding maximum acceptable level of 7.0 are underlined.

TABLE 21. Total suspended particulate matter (µg/m³), Thunder Bay, 1983.

Station	Number of samples	Annual geometric mean	Number of samples above 120 µg/m³	Maximum 24-hour value
63005	54	36	1	122[a]
63012	54	33	1	144
63022	53	36	nil	104
63040	57	36	nil	99
63046	54	55	6	175
63052	48	40	3	146

[a]Values exceeding the maximum acceptable limit of 120 µg/m³ (24-hour average) or 60 µg/m³ (annual geometric mean) are underlined.

TABLE 22. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1983[a].

Station	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.02	<0.01
63040	435 S. James Street	<0.001	0.04	0.01
63041[b]	Mt. McKay		0.26	0.04
63042[b]	East End		0.09	0.02
63044[b]	James St./Kam River		0.17	0.04
63048[b]	Ford Street		0.03	<0.01
63049[b]	Chippewa Park		0.07	0.02
63050[b]	Paipoonge		0.02	<0.01
63051[b]	John Street Landfill		0.05	<0.01

[a]12 months of data for all stations except for 63041 (11 months), 63048 (10 months), and stations 63050 and 63051 (9 months).

[b]Ontario Hydro. 1983-84. Environmental Quality Compliance Reports, 1983. Central Thermal Services, Thermal Generating Division.

TABLE 23. Summary of total reduced sulphur concentrations (ppb), staton 63046, Thunder Bay, 1977-1983.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1977	298	1.5	56	17
1978	280	1.9	48	28
1979	218	2.6	58	26
1980	220	2.9	131	90
1981	340	2.8	72	74
1982	299	1.0	36	7
1983	305	0.5	36	3